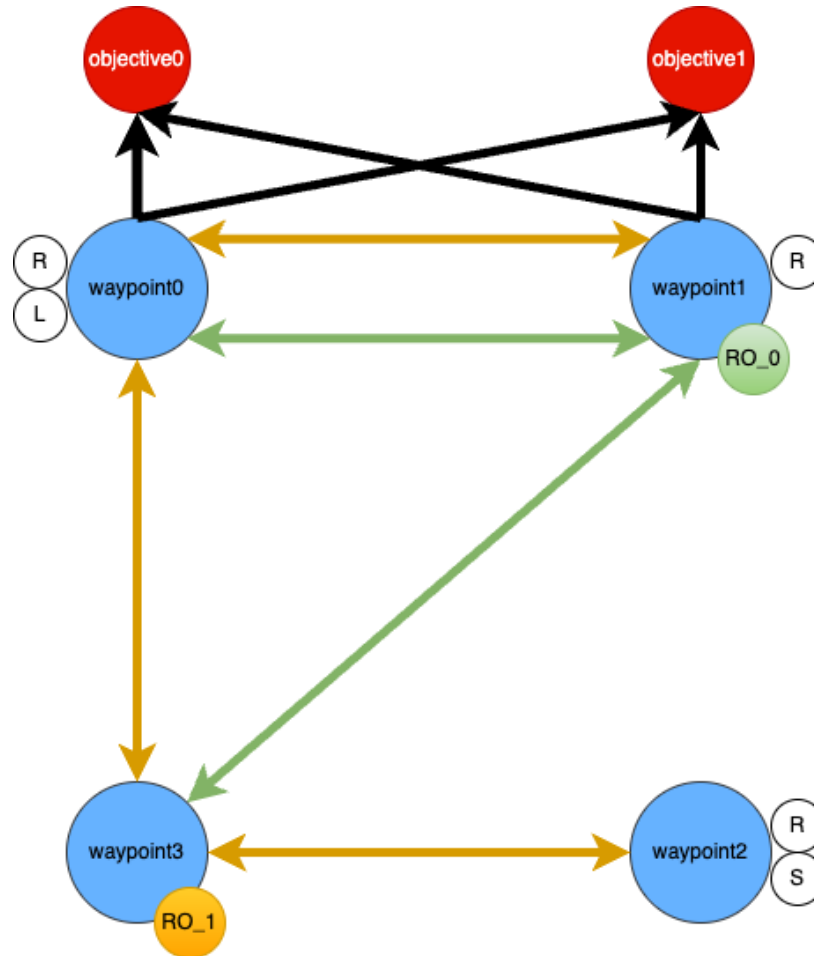


1 Domain Overview

1.1 Graph representation

The following graph represents the initial state of the **Rover domain** used in the PDDL files provided. For clarity, visibility relations between waypoints are omitted: all waypoints are fully connected (i.e., they form a complete graph).



- **Rover** rover0 (**RO_0**) is initially located at **waypoint1** and can traverse between waypoints connected by **yellow edges**.
- **Rover** rover1 (**RO_1**) is initially located at **waypoint3** and can traverse between waypoints connected by **green edges**.
- **Rock samples** are available at waypoints: **waypoint0**, **waypoint1**, and **waypoint2**.
- A **soil sample** is available at **waypoint2**.
- The **lander** object (**L**) is located at **waypoint0**.
- **Objectives** (such as imaging or sampling goals) are visible from **waypoint0** and **waypoint1**, indicated by **black edges**.

1.2 Rover Capabilities

Rover	Camera	Capabilities
rover0	camera0 (low_res)	Soil, rock, imaging (objective1)
rover1	camera1 (low_res, high_res, colour)	Soil, rock, imaging (objective0)

2 Goals and Execution Requirements

To solve the given PDDL problem, the following goals must be achieved by executing appropriate actions with the available rovers. Each goal specifies which rover can complete it, and the necessary actions to achieve the desired state.

- **Communicate Soil Data (Waypoint 2):**
 - **Responsible rover:** rover1 (no path to waypoint2 for rover0)
 - **Action:** Collect soil at waypoint 2 and transmit the data to the lander.
- **Communicate Rock Data (Waypoint 0):**
 - **Responsible rover:** rover0 or rover1
 - **Action:** Collect rock at waypoint 0 and transmit the data to the lander.
- **Communicate Image Data (Objective 0, Colour):**
 - **Responsible rover:** rover1 (no Colour mode for camera on rover0)
 - **Action:** Calibrate the camera, capture an image of objective 0 in colour mode, and transmit the image data to the lander.

3 Regression planning

In this section, we will explore the regression planning approach used in the exercise. We will begin by addressing the goals for rover0, followed by the goals for rover1.

$$Goal = \{communicated_rock_data(waypoint0)\}$$

Action:	<i>communicate_rock_data(rover0, general, waypoint0, waypoint1, waypoint0)</i>
Preconditions:	<i>at(rover0, waypoint1), at_lander(general, waypoint0), have_rock_analysis(rover0, waypoint0), visible(waypoint1, waypoint0), available(rover0), channel_free(general)</i>
Delete list:	<i>available(rover0), channel_free(general)</i>
Add list:	<i>available(rover0), channel_free(general), communicated_rock_data(waypoint0)</i>

$Goal_{-1} = \{at(rovers0, waypoint1), at_lander(general, waypoint0),$
 $have_rock_analysis(rovers0, waypoint0), visible(waypoint1, waypoint0),$
 $available(rovers0), channel_free(general)\}$

Action:	<i>navigate(rovers0, waypoint0, waypoint1)</i>
Preconditions:	<i>can_traverse(rovers0, waypoint0, waypoint1), available(rovers0),</i> <i>at(rovers0, waypoint0), visible(waypoint0, waypoint1)</i>
Delete list:	<i>at(rovers0, waypoint0)</i>
Add list:	<i>at(rovers0, waypoint1)</i>

$Goal_{-2} = \{at(rovers0, waypoint0), at_lander(general, waypoint0),$
 $have_rock_analysis(rovers0, waypoint0), visible(waypoint1, waypoint0),$
 $available(rovers0), channel_free(general),$
 $can_traverse(rovers0, waypoint0, waypoint1),$
 $visible(waypoint0, waypoint1)\}$

Action:	<i>sample_rock(rovers0, rovers0store, waypoint0)</i>
Preconditions:	<i>at(rovers0, waypoint0), at_rock_sample(waypoint0),</i> <i>equipped_for_rock_analysis(rovers0), store_of(rovers0store, rovers0),</i> <i>empty(rovers0store)</i>
Delete list:	<i>empty(rovers0store), at_rock_sample(waypoint0)</i>
Add list:	<i>full(rovers0store), have_rock_analysis(rovers0, waypoint0),</i>

$Goal_{-3} = \{at(rovers0, waypoint0), at_lander(general, waypoint0),$
 $visible(waypoint1, waypoint0), available(rovers0), channel_free(general),$
 $can_traverse(rovers0, waypoint0, waypoint1), visible(waypoint0, waypoint1)$
 $at_rock_sample(waypoint0), equipped_for_rock_analysis(rovers0),$
 $store_of(rovers0store, rovers0), empty(rovers0store)\}$

Action:	<i>navigate(rovers0, waypoint1, waypoint0)</i>
Preconditions:	<i>can_traverse(rovers0, waypoint1, waypoint0), available(rovers0),</i> <i>at(rovers0, waypoint1), visible(waypoint1, waypoint0)</i>
Delete list:	<i>at(rovers0, waypoint1)</i>
Add list:	<i>at(rovers0, waypoint0)</i>

$Goal_{-4} = \{$ **at(rovers0, waypoint1)** $,$ *at_lander(general, waypoint0)* $,$
visible(waypoint1, waypoint0) $,$ *available(rovers0)* $,$ *channel_free(general)* $,$
can_traverse(rovers0, waypoint0, waypoint1) $,$ *visible(waypoint0, waypoint1)* $,$
at_rock_sample(waypoint0) $,$ *equipped_for_rock_analysis(rovers0)* $,$
store_of(rovers0store, rovers0) $,$ *empty(rovers0store)*
can_traverse(rovers0, waypoint1, waypoint0) $,$
visible(waypoint1, waypoint0) $\}$

$Goal = \{communicated_soil_data(waypoint2)\}$

Action:	<i>communicate_soil_data(rovers1, general, waypoint2, waypoint2, waypoint0)</i>
Preconditions:	<i>at(rovers1, waypoint2)</i> $,$ <i>at_lander(general, waypoint0)</i> $,$ <i>have_soil_analysis(rovers1, waypoint2)</i> $,$ <i>visible(waypoint2, waypoint0)</i> $,$ <i>available(rovers1)</i> $,$ <i>channel_free(general)</i> .
Delete list:	<i>available(rovers1)</i> $,$ <i>channel_free(general)</i> .
Add list:	<i>available(rovers1)</i> $,$ <i>channel_free(general)</i> $,$ <i>communicated_soil_data(waypoint2)</i> .

$Goal_{-5} = \{$ **at(rovers1, waypoint2)** $,$ **at_lander(general, waypoint0)** $,$
have_soil_analysis(rovers1, waypoint2) $,$ **visible(waypoint2, waypoint0)** $,$
available(rovers1) $,$ **channel free(general)** $\}$

Action:	<i>sample_soil(rovers1, rovers1store, waypoint2)</i>
Preconditions:	<i>at(rovers1, waypoint2)</i> $,$ <i>at_soil_sample(waypoint2)</i> $,$ <i>equipped_for_soil_analysis(rovers1)</i> $,$ <i>store_of(rovers1store, rovers1)</i> $,$ <i>empty(rovers1store)</i>
Delete list:	<i>empty(rovers1store)</i> $,$ <i>at_soil_sample(waypoint2)</i>
Add list:	<i>full(rovers1store)</i> $,$ <i>have_soil_analysis(rovers1, waypoint2)</i> $,$

$Goal_{-6} = \{$ *at(rovers1, waypoint2)* $,$ *at_lander(general, waypoint0)* $,$
visible(waypoint2, waypoint0) $,$ *available(rovers1)* $,$
channel_free(general) $,$ **at_soil_sample(waypoint2)** $,$
equipped_for_soil_analysis(rovers1) $,$ **store_of(rovers1store, rovers1)** $,$
empty(rovers1store) $\}$

Action:	<i>navigate(rover1, waypoint3, waypoint2)</i>
Preconditions:	<i>can_traverse(rover1, waypoint3, waypoint2), available(rover1), at(rover1, waypoint3), visible(waypoint3, waypoint2)</i>
Delete list:	<i>at(rover1, waypoint3)</i>
Add list:	<i>at(rover1, waypoint2)</i>

$Goal_7 = \{ \mathbf{at(rover1, waypoint3)}, at_lander(general, waypoint0), visible(waypoint2, waypoint0), available(rover1), channel_free(general), at_soil_sample(waypoint2), equipped_for_soil_analysis(rover1), store_of(rover1store, rover1), empty(rover1store), can_traverse(rover1, waypoint3, waypoint2), \mathbf{visible(waypoint3, waypoint2)} \}$

$Goal = \{ at(rover1, waypoint3), at_lander(general, waypoint0), visible(waypoint2, waypoint0), available(rover1), channel_free(general), at_soil_sample(waypoint2), equipped_for_soil_analysis(rover1), store_of(rover1store, rover1), empty(rover1store), can_traverse(rover1, waypoint3, waypoint2), visible(waypoint3, waypoint2), \mathbf{communicated_image_data(objective0, colour)} \}$

Action:	<i>navigate(rover1, waypoint1, waypoint3)</i>
Preconditions:	<i>can_traverse(rover1, waypoint1, waypoint3), available(rover1), at(rover1, waypoint1), visible(waypoint1, waypoint3)</i>
Delete list:	<i>at(rover1, waypoint1)</i>
Add list:	<i>at(rover1, waypoint3)</i>

$Goal_8 = \{ \mathbf{at(rover1, waypoint1)}, at_lander(general, waypoint0), visible(waypoint2, waypoint0), available(rover1), channel_free(general), at_soil_sample(waypoint2), equipped_for_soil_analysis(rover1), store_of(rover1store, rover1), empty(rover1store), can_traverse(rover1, waypoint3, waypoint2), visible(waypoint3, waypoint2), communicated_image_data(objective0, colour), \mathbf{can_traverse(rover1, waypoint1, waypoint3), visible(waypoint1, waypoint3)} \}$

Action:	<i>communicate_image_data(rover1, general, objective0, colour, waypoint1, waypoint0)</i>
Preconditions:	<i>at(rover1, waypoint1), at_lander(general, waypoint0), have_image(rover1, objective0, colour), visible(waypoint1, waypoint0), available(rover1), channel_free(general)</i>
Delete list:	<i>available(rover1), channel_free(general)</i>
Add list:	<i>available(rover1), channel_free(general), communicated_image_data(objective0, colour)</i>

$Goal_9 = \{at(rover1, waypoint1), at_lander(general, waypoint0),$
 $visible(waypoint2, waypoint0), available(rover1),$
 $channel_free(general), at_soil_sample(waypoint2),$
 $equipped_for_soil_analysis(rover1), store_of(rover1store, rover1),$
 $empty(rover1store), can_traverse(rover1, waypoint3, waypoint2),$
 $visible(waypoint3, waypoint2),$
 $can_traverse(rover1, waypoint1, waypoint3), visible(waypoint1, waypoint3),$
 $have_image(rover1, objective0, colour), visible(waypoint1, waypoint0)\}$

Action:	<i>take_image(rover1, waypoint1, objective0, camera1, colour)</i>
Preconditions:	<i>calibrated(camera1, rover1), on_board(camera1, rover1), equipped_for_imaging(rover1), supports(camera1, colour), visible_from(objective0, waypoint1), at(rover1, waypoint1)</i>
Delete list:	<i>calibrated(camera1, rover1)</i>
Add list:	<i>have_image(rover1, objective0, colour)</i>

$Goal_{10} = \{at(rover1, waypoint1), at_lander(general, waypoint0),$
 $visible(waypoint2, waypoint0), available(rover1),$
 $channel_free(general), at_soil_sample(waypoint2),$
 $equipped_for_soil_analysis(rover1), store_of(rover1store, rover1),$
 $empty(rover1store), can_traverse(rover1, waypoint3, waypoint2),$
 $visible(waypoint3, waypoint2),$
 $can_traverse(rover1, waypoint1, waypoint3), visible(waypoint1, waypoint3),$
 $have_image(rover1, objective0, colour), visible(waypoint1, waypoint0),$
 $calibrated(camera1, rover1), on_board(camera1, rover1),$
 $equipped_for_imaging(rover1), supports(camera1, colour),$
 $visible_from(objective0, waypoint1)\}$

Action:	<i>calibrate(rovers1, camera1, objective0, waypoint1)</i>
Preconditions:	<i>equipped_for_imaging(rovers1), calibration_target(camera1, objective0), at(rovers1, waypoint1), visible_from(objective0, waypoint1), on_board(camera1, rovers1)</i>
Delete list:	None
Add list:	<i>calibrated(camera1, rovers1)</i>

$Goal_{-11} = \{at(rovers1, waypoint1), at_lander(general, waypoint0),$
visible(waypoint2, waypoint0), available(rovers1),
channel_free(general), at_soil_sample(waypoint2),
equipped_for_soil_analysis(rovers1), store_of(rovers1store, rovers1),
empty(rovers1store), can_traverse(rovers1, waypoint3, waypoint2),
visible(waypoint3, waypoint2),
can_traverse(rovers1, waypoint1, waypoint3), visible(waypoint1, waypoint3),
have_image(rovers1, objective0, colour), visible(waypoint1, waypoint0),
on_board(camera1, rovers1), equipped_for_imaging(rovers1),
supports(camera1, colour), visible_from(objective0, waypoint1),
calibration_target(camera1, objective0)}

Action:	<i>navigate(rovers1, waypoint3, waypoint1)</i>
Preconditions:	<i>can_traverse(rovers1, waypoint3, waypoint1), available(rovers1), at(rovers1, waypoint3), visible(waypoint3, waypoint1)</i>
Delete list:	<i>at(rovers1, waypoint3)</i>
Add list:	<i>at(rovers1, waypoint1)</i>

$Goal_{-12} = \{at(rovers1, waypoint3), at_lander(general, waypoint0),$
visible(waypoint2, waypoint0), available(rovers1),
channel_free(general), at_soil_sample(waypoint2),
equipped_for_soil_analysis(rovers1), store_of(rovers1store, rovers1),
empty(rovers1store), can_traverse(rovers1, waypoint3, waypoint2),
visible(waypoint3, waypoint2),
can_traverse(rovers1, waypoint1, waypoint3), visible(waypoint1, waypoint3),
have_image(rovers1, objective0, colour), visible(waypoint1, waypoint0),
on_board(camera1, rovers1), equipped_for_imaging(rovers1),
supports(camera1, colour), visible_from(objective0, waypoint1),
calibration_target(camera1, objective0),
can_traverse(rovers1, waypoint3, waypoint1),
visible(waypoint3, waypoint1)}

Regression Planning Result

The following is the sequence of actions derived from **regression planning**, structured to achieve the specified goals:

1. `navigate(rover1, waypoint3, waypoint1)`
2. `calibrate(rover1, camera1, objective0, waypoint1)`
3. `take_image(rover1, waypoint1, objective0, camera1, colour)`
4. `communicate_image_data(rover1, general, objective0, colour, waypoint1, waypoint0)`
5. `navigate(rover1, waypoint1, waypoint3)`
6. `navigate(rover1, waypoint3, waypoint2)`
7. `sample_soil(rover1, rover1store, waypoint2)`
8. `communicate_soil_data(rover1, general, waypoint2, waypoint2, waypoint0)`
9. `navigate(rover0, waypoint1, waypoint0)`
10. `sample_rock(rover0, rover0store, waypoint0)`
11. `navigate(rover0, waypoint0, waypoint1)`
12. `communicate_rock_data(rover0, general, waypoint0, waypoint1, waypoint0)`